[0090] The operations from box **101** to box **111** are successively or periodically repeated until overall system is halted. Through the operation shown in FIG. **12**, real time control module **21** entirely controls the energy supply system to which electric powers are supplied from various power sources such that cost and fuel optimization based on the predictions is achieved. Especially, certain priorities are given to the various power sources and the optimization is carried out by using the priorities. For example, priorities of 1, 2, 3 and 4 are assigned to the renewables, the grid, the energy storage and the generator, respectively.

[0091] Generally, the time variant discharge rate is a consequence of the load to feed and, if available, power generated at the renewable power source such as a PV generation. The charge rate resulting from the load to feed and the energy storage charging power which for efficiency is set at highest rate that does not compromise battery life.

[0092] An example of blackout duration probability function prediction module **34** is illustrated in FIG. **13**. The inputs to module **34** are variables such as month, day of the week, hour, outside temperature, season and other parameters which describe the current environmental situation of the grid and concrete site to be considered. Blackout duration probability function prediction module **34** includes: various and at least two artificial intelligence based predictors (AI predictors) **41** predicting specific blackout durations with an indication of the reliability of the prediction; database **42** storing historical data necessary for predicting the blackout durations; and distribution generator **43**. Artificial intelligence based predictors **41** may be, for example, an artificial neural network (ANN), support vector machine (SVM), and so on. With the results of prediction by artificial intelligence based predictors **41**, distribution generator **43** creates a blackout duration probability function which is used for optimization as explained before.

[0093] In FIG. **14**, a practical example of the application of the present exemplary embodiment is illustrated in form of an energy management system for energy supply of a base transceiver station (BTS) for a rural site in a developing country. The illustrated system includes: Li-ion battery **51** as an energy storage, load **52** including BTS equipment and air conditioning; Diesel engine generator **53** as an energy generator; physical connection apparatus **55**; PV generation **56** as a renewable generation; unreliable grid supply **57** such as one in a rural area in a developing country with blackout(s) everyday; and prediction server **60**. In this example, prediction server **60** is implemented by using cloud solution. Therefore, the functionality of prediction server **60** may be realized by various resources in the cloud which are available via network accesses. Diesel engine generator **53** supplies DC power and has PDE characteristic shown in FIG. **3**C. Local controller **54** which is implemented by an industrial PC (personal computer) is arranged in physical connection apparatus **55**. Local controller **54** and prediction server **60** are connected with each other via communication link **58** which is, for example, a GPRS channel.

[0094] FIG. **15** illustrates in detail the system shown in FIG. **14**. Physical connection apparatus **55** includes: DC bus **61** for distributing DC power; AC bus **62** for distributing AC power; DC/AC convertor **63** arranged between DC bus **61** and AC bus **62**; and AC/DC converter **64** arranged between DC bus **61** and AC bus **62**. Li-ion battery **51** is connected to DC bus **61** via charger/discharger **65** which includes a DC/DC converter. PV generation **56** outputting DC power is connected to DC bus **61** via MPPT (maximum power point tracking) unit **66**. Diesel engine generator **53** and unreliable grid supply **57** are connected to AC bus **62**.

[0095] Load **52** includes: BTS unit **71** with constant DC power consumption; free cooling unit **72** which consumes DC power depending on the temperature; and air conditioning **73** which consumes AC power depending on the temperature. BTS unit **71** and free cooling unit **72** are connected to DC bus **61** while air conditioning **73** is connected to AC bus **62**.

[0096] Local controller **54** gives commands as charge/discharge power to charger/discharger **65** to control charging and discharging of Li-ion battery **57**. Local controller **54** gives Diesel generator on/off commands to Diesel engine generator **53**. The concrete realization of the charge/discharge power is done by setting the voltage of DC bus **61**. This voltage control is realized by other well-known methods which are not explicitly explained, since they are not part of the present invention.

[0097] Prediction server **60** implements the basic prediction functions for load prediction based on weather prediction and modelling of the air conditioning, PV generation prediction and the blackout duration probability function prediction. The prediction data obtained by prediction server **60** is transferred from time to time to local controller **54**. Local controller **54** uses the transferred data to compute ideal discharge and charge limits for the real time control module. In addition, from time to time data is transferred from local controller **54** to prediction server **60** to improve the quality of the prediction by prediction server **60** by self-learning.

[0098] Simulation of operation of the system shown in FIGS. **14** and **15** was carried out to show the validity of the exemplary embodiment. FIGS. **16**A to **16**H show the results for the various simulation items. Operation within a period of 24 hours, i.e., an entire day, was simulated. In the simulation, it was assumed that blackout occurs from 03:00 AM to 09:00 PM as shown FIG. **16**H. The air conditioning, i.e., AC load, is operated from around 06:00 AM to around 08:00 PM. Due to availability of load prediction (FIG. **16**G), PV generation prediction (FIG. **16**H) and blackout duration probability function, the optimization method is able to compute optimal lower discharging limit $p_{low}(t)$ and higher charging limit $p_{high}(t)$ as shown in FIG. **16**A. These two limits $p_{low}(t)$ and $p_{high}(t)$ are input to the real time control module which controls the charging/discharging of the battery and the diesel engine operation. The resultant SOC change of the Li-ion battery, charging/discharging power, Diesel generator power and grid supplied power are shown in FIG. **16**A to **16**D, respectively. Cost can be calculated from the Diesel generator power, grid supplied power and the number of the generator starts, and the results of cost calculation are shown in FIGS. **16**E and **16**F.

[0099] As describe above, the intelligent energy management system (IEMS) according to the exemplary embodiment allows for optimal or near optimal operation of the energy supply system under reduced information by use of the prediction technology, especially the new prediction method of the blackout duration probability function prediction to deal with unplanned blackouts, and the special optimization method computing the lower and upper limits $p_{low}(t)$ and $p_{high}(t)$. The optimization method to include the blackout duration probability function uses a special optimization criterion in order to gain robust results and achiev-